Space Weather Technical Forecast

Issued on Wednesday, 07 December 2022 at 12:50 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-Class flares throughout. Chance of G1/Minor Storm late day 1 or day 2 (7th-8th). Chance of Active electron fluence each day, becoming likely day 4 (10th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been low over the past 24 hours, with several low level C-class flares observed. There are eight sunspot regions on the Earth-facing side of the Sun, with the disc dominated by a large region in the south centre disk which, despite its size, remains stable. The remaining spots on the disk have shown little growth and remained relatively stable.

There is no evidence of any Earth-bound Coronal Mass Ejections (CMEs) in available satellite imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR, were at background levels around 330-370 km/s, with a recent upward trend due to the approaching fast wind of CH53/-. The solar wind density was below average for much of the period, with a recent rising trend, becoming above average, with a max reading of 36ppcc at 07/1200 UTC. The IMF Bt, was weak initially, before becoming moderate from 07/0900 UTC, reaching 14 nT by 07/0950 UTC. The north-south range followed a similar trend, becoming mostly moderately negative toward the end of the period, ranging from +3 to -13nT. The phi angle remained accordingly positive (away from the Sun) throughout. Geomagnetic activity was Quiet for much of the period (Kp 0-1) with the final 0900-1200 UTC interval becoming Unsettled (Kp 3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 has remained at Background levels.

High energy electron flux (greater than 2MeV) at GOES16 ranged between Moderate and High in the period, peaking at 2250 pfu at 06/1705 UTC. The associated 24-hour Fluence remained just below the Active (1e8 integrated pfu) threshold through the period. Observed fluence at 07/0001 UTC was 8.85e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to remain at Low levels, with occasional C-class flares and a Chance of isolated M-class flares, most likely from AR3158 or AR3157. No significant regions are expected to arrive or depart in the next four days.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs have been observed on available imagery. Solar wind speeds are currently at slow-ambient levels, but are on a gradual incline due to CH53/-. This enhancement will likely continue through the end of day 1 (7th) and into day 2 (8th), with a chance of elevated wind speeds. Winds expected to gradually ease by the end of the period as HSS influence from CH53/- wanes.

Geomagnetic activity is expected to be Quiet initially with a chance of isolated Unsettled intervals. The arrival of the HSS from late day 1 sees Active intervals become likely, with a peak Chance of G1/Minor Storms spanning days 1 and 2 (7th/8th). Geomagnetic activity is expected to return to Quiet as connection to the HSS weakens on Days 3 and 4 (9th/10th).

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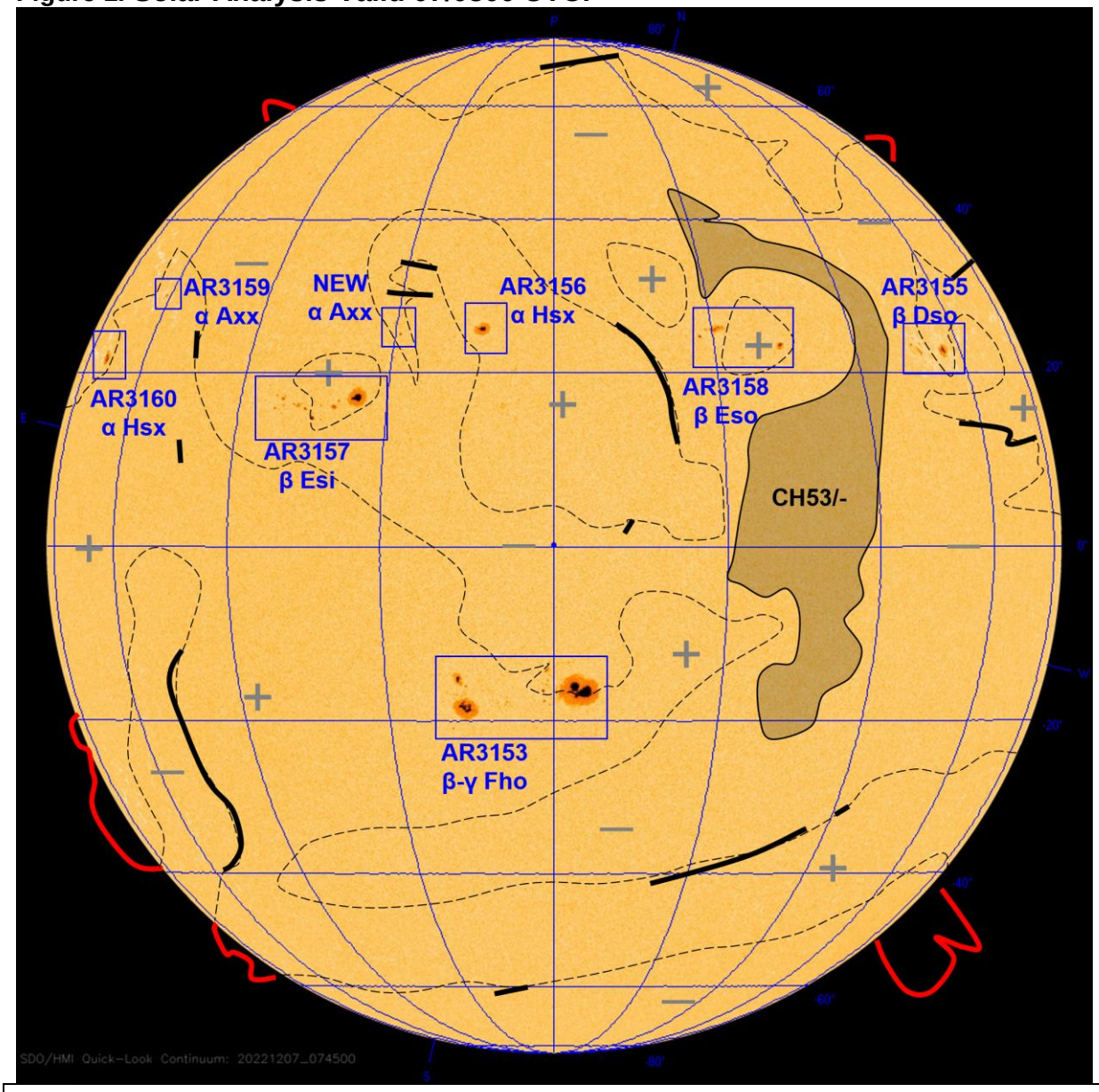
Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels throughout, with a daily Very Slight Chance of seeing S1 levels if any significant flares were to occur. High energy electron flux (greater than 2 MeV), as observed by GOES16, is expected to continue its current diurnal oscillation between Moderate and High levels. Flux levels are expected to fall during day 1 (7th) or early day 2 (8th) in response to geomagnetic activity related to CH53/-. As influence from the HSS wanes, a recovery in electron flux levels is probable either day 3 or 4 (9th/10th Dec).

Fluence levels are currently at Background levels, but very close to the Active threshold (1e8 integrated pfu). Fluence may cross the Active threshold on day 1 (7th), followed by a probable declining trend due to HSS disruption. Recovery in levels likely on day 3 or 4 (9th/10th), giving a chance of Active fluence.

Figure 1. Solar Analysis Valid 07/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth-directed CMEs have been observed on available imagery.

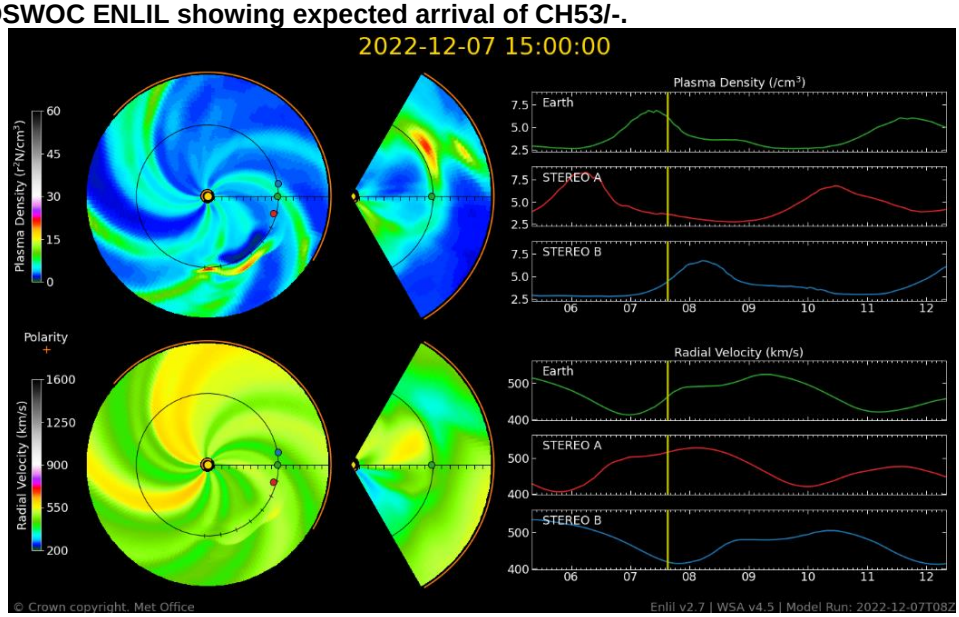
Solar wind speeds are currently at slow-ambient levels, but are on a gradual incline as we start to see CIR influence from the expected HSS from CH53/-. This enhancement will likely continue through the end of day 1 (7th) and into day 2 (8th). CH53/- is a large coronal hole which dominates the western disc in SDO/AIA 211 and 193 imagery. This recurrent feature is larger and much more pronounced relative to the last rotation. Uncertainty as to the effect of this feature lies with these changes as well as the temporal proximity to the solstice and bi-annual minima. Winds expected to gradually ease by the end of the period as HSS influence wanes.

The effects of CH53/- are evident STEREO A, with slightly elevated wind speeds and Moderate IMF Bt readings, with some periods of moderately negative Bz. MOSWOC Enlil suggests a peak winds of 550 km/s arriving on day 2 (8th), however onset late on day 1 is possible with strengths of 550-600 km/s.

Geomagnetic activity is expected to be Quiet initially with a chance of isolated Unsettled intervals. The arrival of the HSS from late day 1 sees Active intervals become likely, with a peak Chance of G1/Minor Storms spanning days 1 and 2 (7th/8th). Geomagnetic activity is expected to return to Quiet as connection to the HSS weakens on days 3 and 4 (9th/10th).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	40	40	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC ENLIL showing expected arrival of CH53/-.



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Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the past 24-hours, with several low levels C-class flares. Activity is likely to remain at Low levels, with a daily Chance of increasing to Moderate through the period.

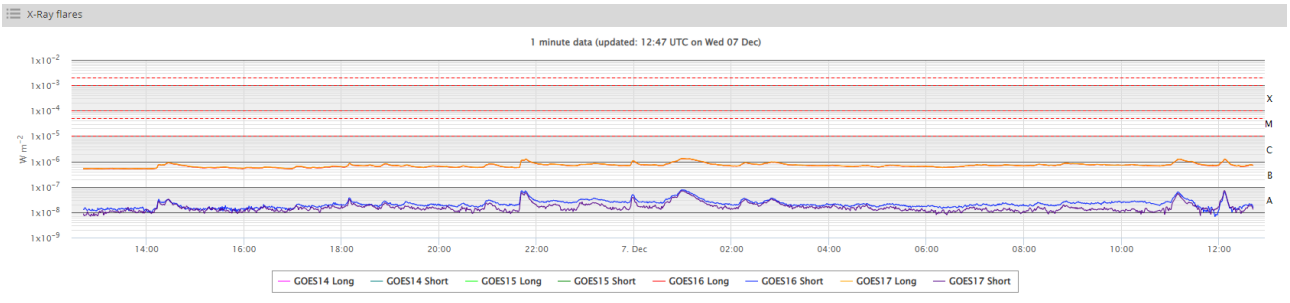
There are currently seven numbered and one unnumbered sunspot regions on the visible disc. By far the largest group on the disc remains AR3153, now centre disk. This region has remained relatively stable, but with a beta/gamma magnetic configuration. The second largest spot group, AR3157, has shown some recent minor growth, though appears to have not developed any further complexity. AR3155, AR3156, AR3158 and AR3160 all remain of modest size with little change. All other spots are small and simple at present.

One further region may emerge over the eastern limb by day 3 (9th), otherwise all the sunspots likely to be present in the period are presently on the visible disc.

Despite the suggested complexity of the regions on the visible disc, this has so far failed to manifest in significant flare activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 3: 24 hour X-Ray trace.



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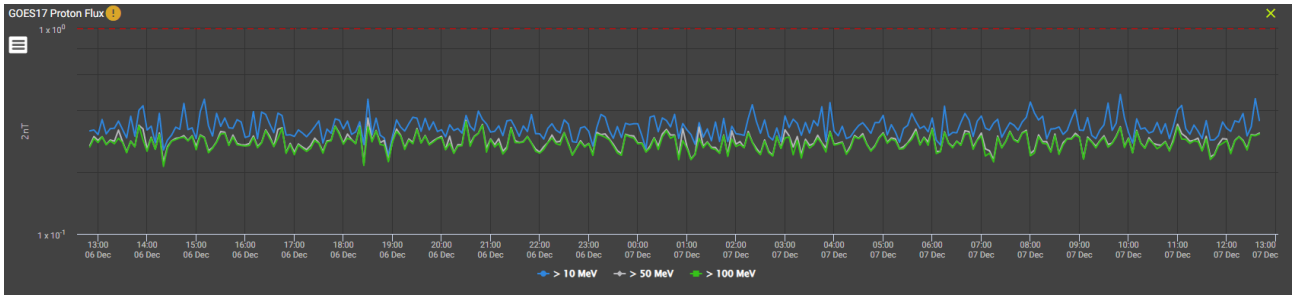
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels throughout. However, there is a daily Very Slight Chance of seeing S1 or greater levels at GEO if any significant flares were to occur. Probabilities are representative of raw values and current sunspot classifications.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour Proton trace.



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High Energy Electrons Event (≥ 2MeV):

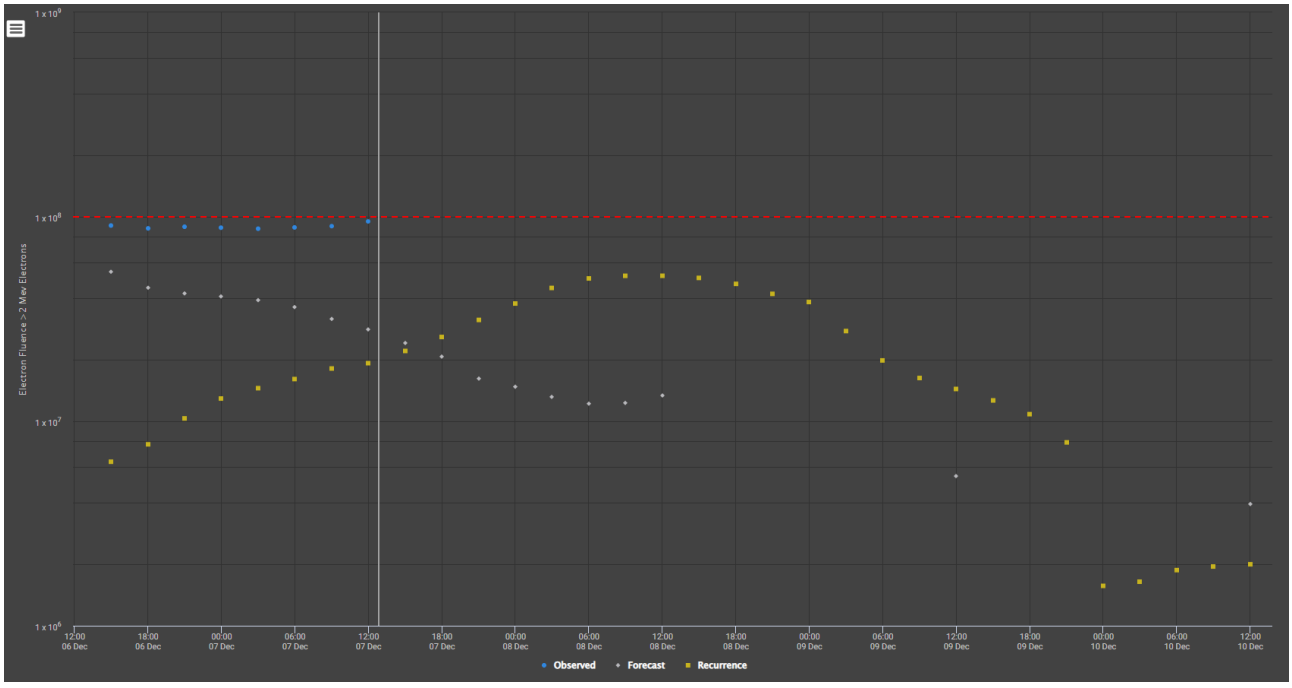
High energy electron flux (greater than 2 MeV), as observed by GOES16, is currently demonstrating a diurnal oscillation between Moderate and High flux levels. This pattern is expected to continue until late day 1 (7th) or early day 2 (8th), at which point geomagnetic activity resulting from the arrival of CH53 may result in disruption and compression of the radiation belt. As influence from the HSS wanes, a recovery in electron flux levels is likely on days 3 and 4 (9th/10th).

Levels of electron fluence are currently at Background levels, but very close to the Active threshold (1e8 integrated pfu). Fluence may cross the Active threshold on Day 1, followed by a probable decline due to the arrival of the HSS and a recovery from day 3 (9th), once more giving a chance of Moderate fluence levels.

Confidence in the above forecast is relatively low, as flux and fluence levels are currently marginal and the driving coronal hole during the period is much-changed from the last rotation

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	40	20	40	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM electrn fluence model/persistence/observations



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